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[54] **APPARATUS FOR HEAT TREATMENT OF FIBROUS MATS**

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[52] **U.S. Cl.** **425/371;** 425/407; 425/446

[58] **Field of Search** 425/363, 371, 372, 405, 425/406, 407, 445

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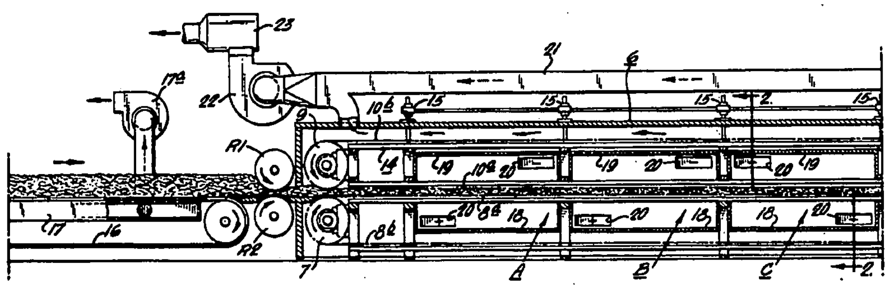
[57] **ABSTRACT**

A technique is disclosed for heat treatment of fibrous mats, especially mats formed of mineral fibers such as glass and carrying a heat hardenable binder material, such as a thermosetting resin. The method and the equipment disclosed provide for continuous feed of the mat through a curing or treating oven having a plurality of heat treatment zones or areas. In one form of the method and equipment, the heat treatment in at least one zone is effected by circulation of a heated gas, such as air, through the mat in said zone, and the mat is also subjected to heat treatment in a localized area lying within said zone by passage of a second heated gas through the mat, the second heated gas having a pressure higher than that in the surrounding portions of said zone.

9 Claims, 7 Drawing Figures



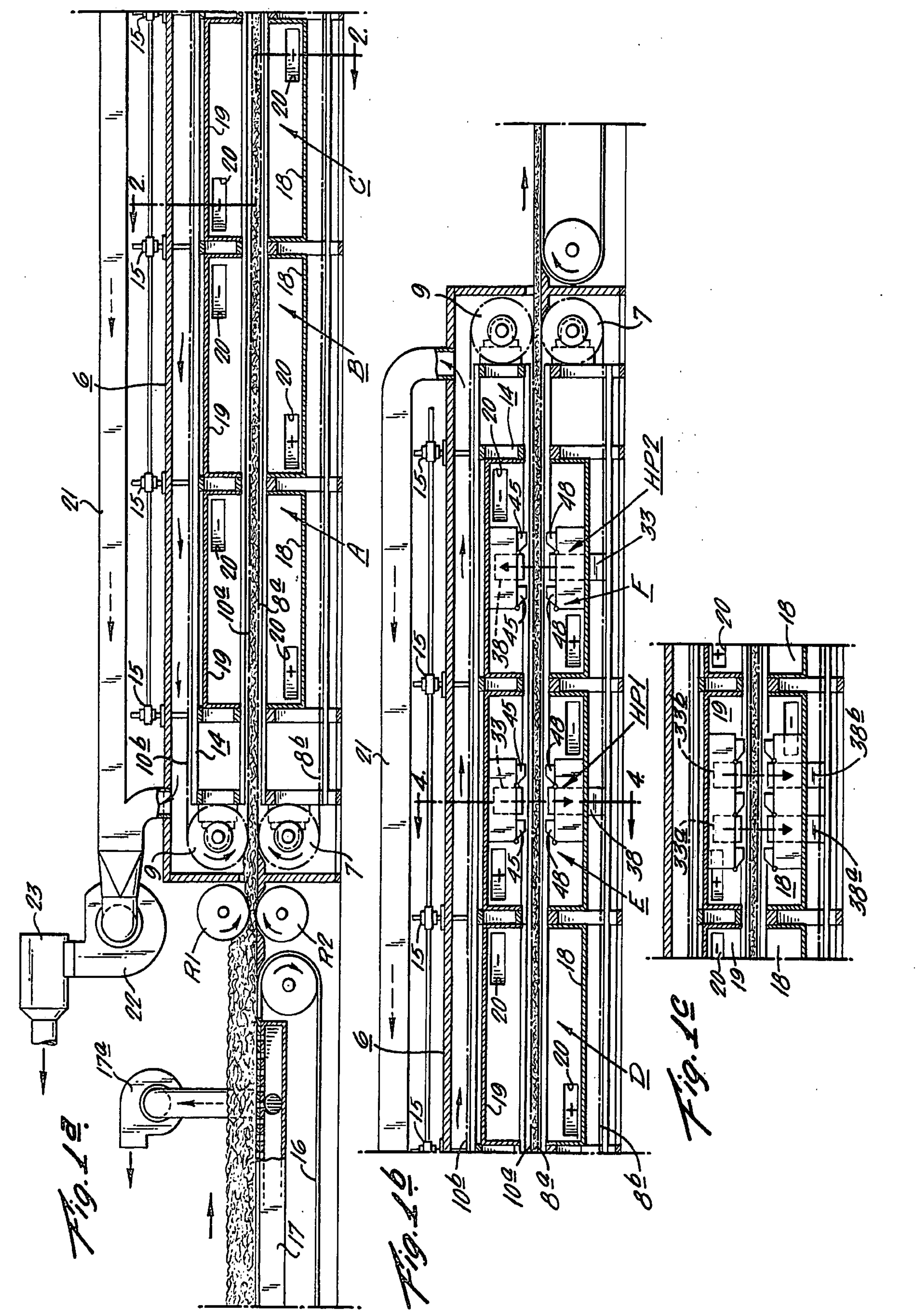


Fig. 1a

Fig. 1b

Fig. 1c

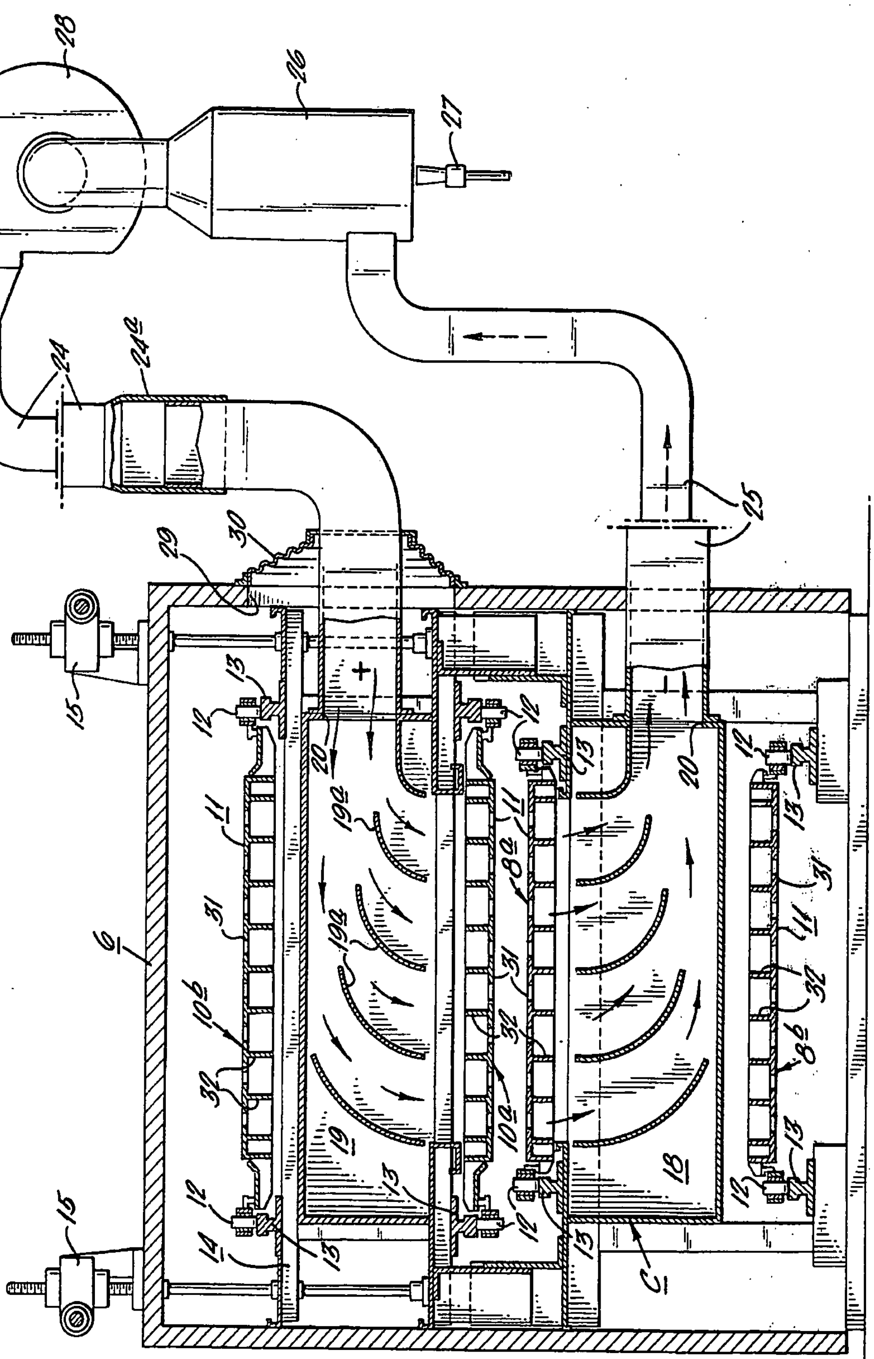

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Fig. 2.

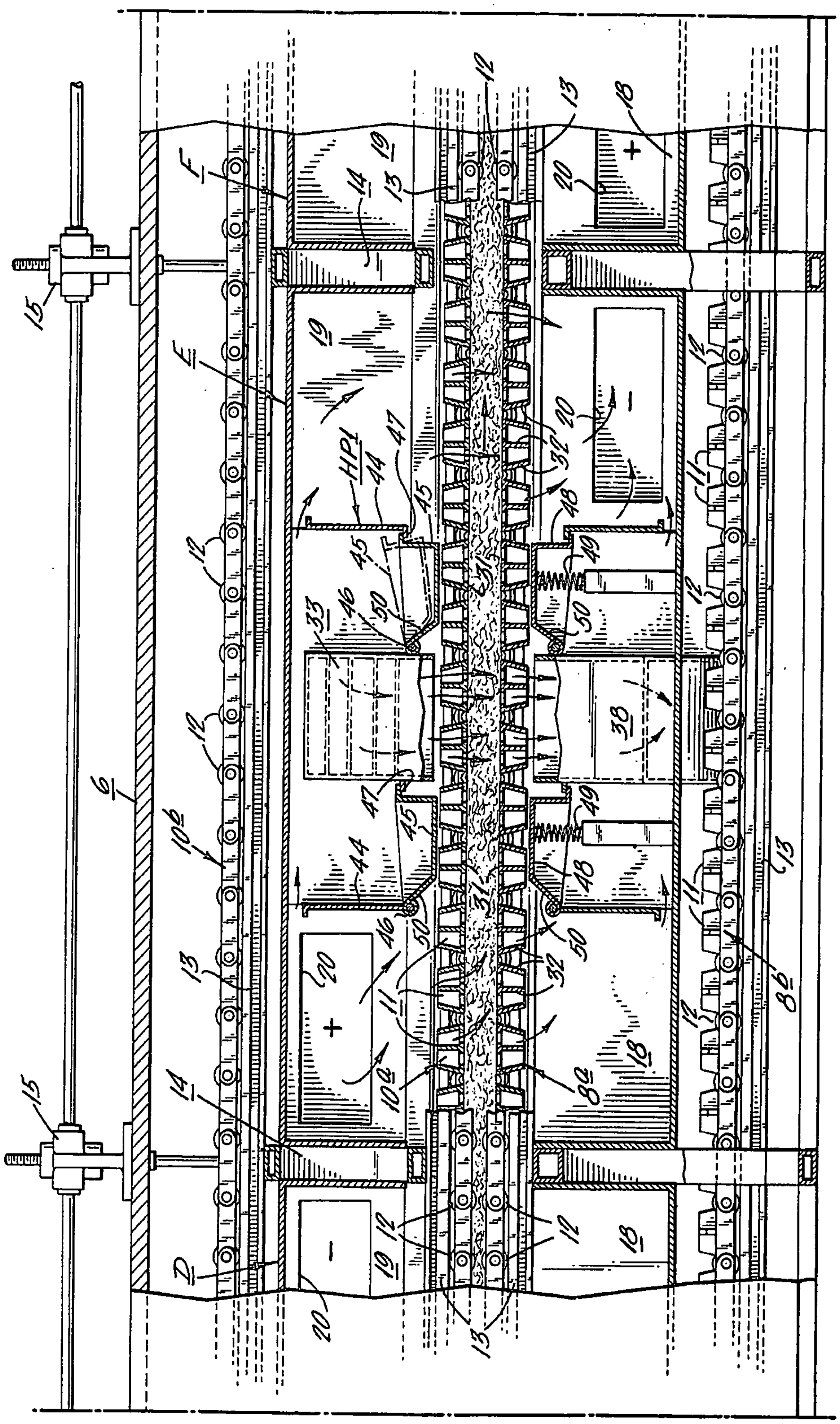

Fig. 3

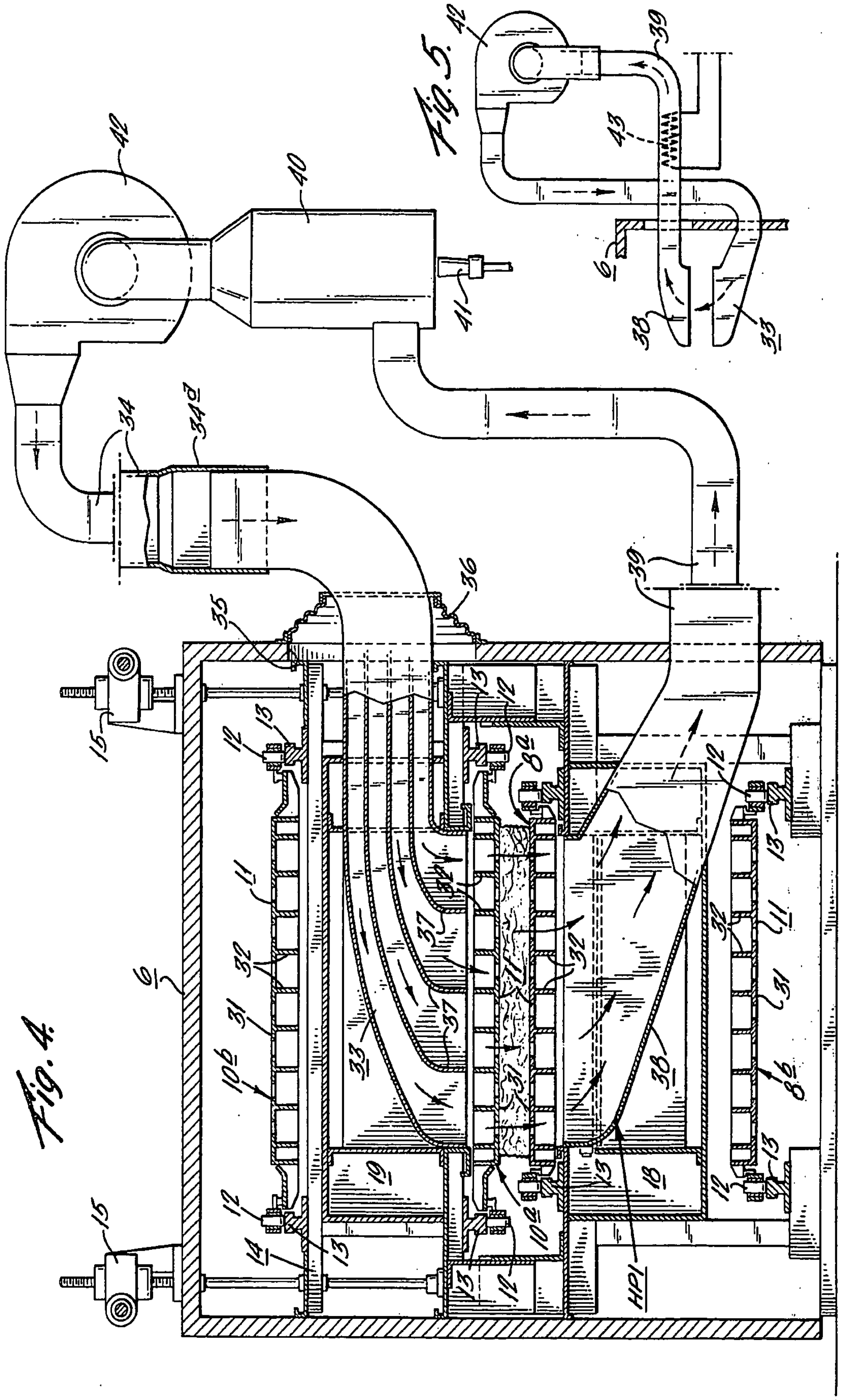

Fig. 5.

Fig. 4.

APPARATUS FOR HEAT TREATMENT OF FIBROUS MATS

BACKGROUND AND STATEMENT OF OBJECTS

In the production of fibrous insulating mats, especially mats formed of glass or similar mineral fibers, it is customary to initially form the mat by depositing the fibers on a perforated moving conveyor, usually with the aid of suction boxes provided under the flight of the conveyor on which the fibers are deposited. It is also customary to deposit a fiber binder on the fibers either before or during the buildup of the mat on the conveyor, such binder having adhesive characteristics and usually comprising a heat curable or hardenable material, such as a thermosetting resin, for instance, a phenol formaldehyde resin sprayed on the fibers in a solution or a suspension in a volatile liquid, such as water.

The layer of blanket of relatively loose fibers on the collecting conveyor is thereafter customarily delivered to what is commonly referred to as a mat curing oven through which the mat is fed by additional perforated conveyor means, frequently comprising a pair of endless conveyors having adjacent flights presented toward each other in spaced relation and serving to determine the thickness of the mat to be formed. Such a mat may be more or less dense, depending upon the extent of compression applied by the pair of conveyors in the mat curing oven.

During passage of the mat through the oven, the mat is subjected to heat treatment to effect curing of the fiber binder and thereby to effect stabilization of the mat at the desired thickness.

For the purpose of effecting the curing of the binder, various techniques have been employed; but quite commonly, the technique includes passage of heated air through the mat, for which purpose circulation boxes or manifolds are arranged in pairs at opposite sides of the feed path of the mat through the curing oven, such ovens quite commonly including several such pairs of circulation boxes, with provision for establishing different temperature conditions sequentially through the series of pairs, so as to regulate the curing temperature applied at different zones in the path of the mat through the curing oven.

It is a principal object of the present invention to provide not only for the heating to effect curing of the binder by the primary heating system in the general manner heretofore contemplated, but in addition, the invention contemplates employment of a second independent heating system comprising at least one pair of manifolds of relatively small size operating in relatively small localized areas at opposite sides of the path of the mat, this pair of manifolds serving to pass through the mat a heated gas having a pressure and temperature sufficiently high to raise the temperature of the core portion of the mat to a higher value than that attained in the core portion in the areas surrounding said localized areas. Moreover, the heated gas of this "secondary" binder curing system is preferably passed through the mat in a localized area located in the mid or downstream portion of the feed path so that the surface layers of the mat have already been cured and stabilized by the primary heating system. This intial stabilization of the surface layers of the mat makes possible the use of relatively high pressure in the secondary heating system without disrupting the fibers of the mat.

Although the arrangement of the invention is adaptable to the curing of a wide variety of mats and fibrous blankets, for reasons noted just above, the invention is especially advantageous in the curing of binder in relatively dense mats, because the pressure and temperature conditions employed in the secondary heating system of the present invention promote rapid penetration of the heat into the interior of even quite dense and thick fibrous products; and since the secondary high pressure air is applied after the surface layers of the mat have been stabilized, this rapid penetration is accomplished without disruption of the fibers.

In a typical installation in which the primary heat curing system involves the use of pairs of hot air circulation boxes arranged in sequence along the feed path through the oven, the invention contemplates, as a secondary heat curing system, the introduction of at least one pair of hot air circulation manifolds having relatively small localized areas lying within the zone or area of one of the pairs of boxes of the primary systems. In this installation, it is contemplated that the heated air of the secondary system operating in the localized area have a pressure higher than that of the air employed in the primary system. When employed in this configuration, the primary air circulation system serves not only to supply heat needed for the curing of the binder, but in addition, it serves also as a means for preventing escape or loss into the atmosphere of air leaking from the secondary system which operates at higher pressure.

By the employment of both primary and secondary systems, and by the employment of a higher pressure in the secondary system, the rapid penetration of the heat into the interior of the mat being cured in the localized area of the secondary manifolds, is highly effective in expediting attainment of the binder curing temperature in the interior or core portion of the mat; and it is an object of the invention to provide for rapid attainment of a binder curing temperature sufficiently high to initiate exothermic reaction of the binder resin. The attainment of such an exothermic temperature will result in continuance of the binder curing, even if succeeding zones of the curing oven are not maintained at the same elevated temperature. Therefore, in the overall curing operation, the use of the secondary high pressure system in the localized downstream curing areas effects an overall economy of the total fuel expended to accomplish the curing.

It is a further object of the invention to provide novel structural arrangements for introducing the high pressure manifolds of the secondary system in the localized areas of the circulation boxes of the primary system, these structural arrangements providing for minimization of shortcircuiting and leakage and also providing automatically for yielding of some of the shielding elements without breakage thereof, in the event of buildup of resin or other deposits on the conveyors serving to carry the mat through the curing oven.

BRIEF DESCRIPTION OF DRAWINGS

How the foregoing and other objects and advantages are attained will appear more fully from the following description referring to the accompanying drawings, in which

FIGS. *1a* and *1b*, taken together, illustrate a longitudinal sectional view through a mat curing oven accord-

ing to the present invention embodying a sequence of six pairs of hot air circulation boxes providing the primary system for the heat treatment or curing, and further a secondary system embodying two pairs of localized high pressure manifolds, one pair being disposed in each of the last two of the primary or low pressure circulation boxes;

FIG. 1c is a fragmentary view similar to a portion of FIG. 1b but illustrating an alternative embodiment in which two pairs of high pressure or secondary circulation boxes are enclosed in one of the pairs of the low pressure circulation boxes;

FIG. 2 is a transverse sectional view on an enlarged scale taken through one of the pairs of primary hot air circulation boxes, as indicated by the section line 2—2 applied to FIG. 1a;

FIG. 3 is a fragmentary longitudinal sectional view on the scale of FIG. 2, illustrating one of the pairs of primary or low pressure circulation boxes having a pair of secondary or high pressure manifolds disposed therein;

FIG. 4 is a view on the same scale as FIGS. 2 and 3 but illustrating a transverse section through a pair of secondary or high pressure circulation manifolds this view being taken as indicated by the section line 4—4 on FIG. 1b; and

Fig. 5 is a fragmentary view on a smaller scale than FIG. 4 but illustrating a modification of the high pressure air circulation system.

DETAILED DESCRIPTION OF THE DRAWINGS

In the drawings, the reference numeral 6 indicates the mat curing oven in general, the oven having enclosing structures or walls within which the conveyor equipment and the hot air circulation systems are arranged.

As seen in FIGS. 1a and 1b, in the lower portion of the oven, rotative supporting elements or rollers 7—7 are provided for mounting the lower endless conveyor, the upper and lower flights of which are indicated in FIGS. 1a and 1b only by dot-dash lines, these conveyor flights appearing in greater detail at 8a and 8b in FIGS. 2, 3 and 4. As seen in FIGS. 1a and 1b, rotative supports or rollers 9—9 are also provided for the upper conveyor, which is indicated in FIGS. 1a and 1b only by dot-dash lines; but the lower and upper flights of which appear in greater detail at 10a and 10b in FIGS. 2, 3 and 4. Each of the conveyors is made up of a multiplicity of links which are pivotally interconnected and which carry rollers 12 adapted to ride on the tracks indicated at 13. The links are generally indicated at 11. Conveyors of this type are driven through the mounting rollers.

The rollers 9 and also the tracks 13 for the upper conveyor are mounted upon a frame structure 14 made up of longitudinal and transverse members interconnected so as to provide for adjustable positioning of the upper conveyor with respect to the lower conveyor. This adjustment may be effected by screw jacks indicated at 15 in a manner well understood in this art and forming no part of the present invention per se.

By virtue of the adjustability of the upper conveyor, the space between the conveyor flights 8a and 10a, which are the runs presented toward the fibrous mat, may be altered in order to establish the desired density or thickness of the product being made.

At the upstream or input end of the oven, a conveyor, indicated diagrammatically at 16, is provided, the conveyor here illustrated representing a perofrated conveyor such as commonly employed for the collection of fibers to form a mat or blanket. Suction boxes, such as shown at 17, may be employed for assisting the collection of the fibers and for maintaining them in position on the conveyor. Suction fans 17a are connected with the suction boxes. The fibrous blanket carried by this conveyor 16 is delivered to the sizing rolls R1–R2, which are preferably adjustable in order to regulate the thickness of the mat being introduced into the oven; and after delivery of the partially sized mat from the rolls R1–R2, the mat enters between the conveyor flights in the curing oven.

Interiorly of the oven, the primary or low pressure sure air circulation boxes are provided in pairs. In the embodiment illustrated in FIGS. 1a and 1b, six such low pressure pairs of boxes appear, the zones or regions of these pairs being generally indicated by the letters A, B, C, D, E and F. These pairs of boxes are generally rectangular and are identified by reference numerals 18 and 19. The boxes are closed on all sides except for the side presented toward the conveyor flights 8a or 10a. Each box 18 is mounted on fixed structure below the upper flight 8a of the lower conveyor; and each box 19 is mounted on the vertically adjustable framing 14 for the upper conveyor, so that the upper boxes move with the upper conveyor when its position is adjusted.

Each box is also provided with an opening communicating with a duct for either supply or exhaust of the treatment gases, such openings being indicated at 20. The supply or inlet and the discharge or exhaust openings are respectively marked with plus and minus symbols—"+" or "−". It will be noted that in the first pair of boxes A, the supply opening 20 is arranged in the lower box 18 toward the upstream end of the box, with respect to the direction of feed of the product through the oven; and the exhaust opening is arranged in the upper box 19 of this pair, near the downstream end.

The same general pattern is repeated in the boxes of the second pair indicated at B. In the third pair of boxes, indicated at C, the inlet opening is in the upper box 19 at the upstream end and the exhaust opening is in the lower box of the pair toward the downstream end.

In the zone indicated at D for the fourth pair of boxes, the pattern of inlet and outlet openings is the same as for pairs A and B. In the pair of boxes E, the arrangement of inlet and outlet conforms with that mentioned above in connection with zone C; and in the pair F, the arrangement shown conforms with that of the boxes D. It is to be understood that these relationships may be altered in order to vary the manner in which the curing is effected; and different flow conditions may be employed in connection with products of different types, thickness and/or densities, as is known in this art. In addition, a smaller or a larger number of circulation boxes and treatment zones may be utilized, according to the nature of the product being made. Still further, the flow through certain boxes may be shut off if desired.

Before considering the structure and operation of the high pressure air circulation system contemplated by the present invention, attention is called to the fact that the overall enclosure of the oven 6 is provided with a gas exhaust system including the ducts 21, and the exhaust fan 22, the latter delivering gases removed from the interior of the oven into and through an appropriate precipitator 23 for separation of suspended solids. The walls of the oven 6, in effect, comprise a hood surrounding the interior components of the oven including the heated gas circulation boxes described above, and the

manifolds which are described hereinafter; and the leakage which occurs is withdrawn from the oven enclosure by the exhaust system just described.

FIG. 2 illustrates on an enlarged scale a transverse section through the low pressure boxes of zone C. Here it will be seen that the gas supply line **24** is connected with the upper or supply box **19** and that the exhaust duct **25** is connected with the lower exhaust circulation box **18**. Vanes **19a** serve to distribute the incoming gas over the width of the conveyor and thus over the width of the mat being treated. The gases discharged through the connection **25** are delivered to a heater **26** with which a burner **27** is associated, and these gases are drawn through the heater by the fan **28** and delivered by the fan into the supply duct **24**. This gas heating and circulation system may be employed for more than one of the pairs of low pressure boxes, of if desired, separate circulation systems may be used.

To accommodate vertical motion of the upper conveyor and the parts mounted therewith, the supply duct **24** extends through an oversized opening **29** in the wall of the oven, and a flexible closure bellows **30** may be used to substantially seal the joint between the supply duct and the wall of the oven. In addition, the duct **24** is provided with a slip joint **24a** to accommodate the vertical adjustment.

In considering the high pressure gas circulation system, attention is first directed to certain features of construction of the conveyors. As above noted, these conveyors are made up of links **11** which are pivoted to each other in an endless loop, one such loop being provided for each conveyor. The individual links (see for example FIGS. **2** and **3**) extend across the width of the conveyor and have rollers **12** associated therewith at each edge of the conveyor, as appears from FIG. **2**. Each link has a base plate **31** which is apertured at intervals across the width of the conveyor (as clearly appears in FIG. **2**), and is provided with projecting ribs or flanges **32** forming transverse passages extended through the links for the flow of the gases from the low pressure supply boxes (described above) or high pressure supply manifolds (described herebelow), through the mat carried by the conveyors and then through the apertures and passages in the links of the other conveyor and into the exhaust boxes or manifolds.

As shown in the embodiment of FIGS. **1a** and **1b**, a high pressure manifold system **HP1** is associated with the pair of low pressure boxes **18** and **19** in zone E, this high pressure system and the pair of low pressure boxes **18** and **19** being illustrated in enlarged longitudinal section in FIG. **3** and in enlarged transverse section in FIG. **4**. From FIGS. **1b** and **3**, it will be seen that the high pressure manifold system is substantially smaller than the low pressure boxes **18** and **19** and further that the high pressure manifold system lies within the low pressure boxes **18** and **19**. The high pressure supply manifold is indicated at **33**; and from comparison of FIGS. **3** and **4**, it will be noted that this manifold extends across the width of the conveyor, above the flight **10a**, and of the mat being treated, but is of relatively short dimension in a direction upstream and downstream of the feed path of the mat. A supply duct **34** is connected with the high pressure supply manifold, this duct passing through an oversized opening **35** in the wall of the oven and the opening being closed by a flexible bellows seal **36**. Duct **34** has a slip joint **34a** to accommodate vertical motion. In the interior of the high pressure supply manifold, vanes **37** are provided to insure distribution of the high pressure gases over the width of the conveyor. A high pressure exhaust manifold **38** is provided below the flight **8a** of the lower conveyor and the exhaust manifold is connected with the duct **39** in order to discharge the high pressure gases after they have passed through the mat being treated. The duct **39** delivers the withdrawn gases to a heater **40** having a burner **41** from which the gases are withdrawn by the fan **42** which recirculates the gases to the supply duct **34**.

As in the low pressure system, the high pressure duct and circulation system, including the heater **40** and the fan **42**, may be employed for more than one high pressure system; or if desired, separate heaters and fans may be utilized for different high pressure systems.

Although distributing vanes **37** are provided in the supply manifold **33**, these are not needed in and are preferably omitted from the exhaust manifold **38**.

FIG. **5** schematically illustrates an alternative form of heater which may be employed for heating the high pressure gases in the circulation system. Here, a heat exchanger diagrammatically indicated at **43**, is introduced into the exhaust manifold **39** in advance of passage of the gases through the fan or blower **42**. FIG. **5** also indicates an alternative arrangement of the high pressure supply and exhaust manifolds **33** and **38**; in this illustration, the supply manifold **33** being located below the mat being treated and the exhaust manifold **38** being located above the mat.

Because of the employment of relatively high pressure gases in the high pressure system, it is of importance to minimize gas leakage, and this requires provision of special sealing devices, an example of such devices being particularly illustrated in FIG. **3**. Here it will be seen that at each side of the upper or supply manifold **33**, a supporting structure **44** is provided, this structure serving to mount a pair of wall elements **45**, one located at each side of the manifold **33**. Each of these wall elements is pivotally mounted as indicated at **46**, so that the wall element may be swung or displaced upwardly away from the upper surface of the conveyor flight **10a**. At a point opposite to the pivot **46**, the wall element **45** is provided with a flange cooperating with a stop or abutment **47** which serves to limit downward movement of the wall element and thus prevents contact of the wall element with the upper surface of the conveyor flight **10a**. Each of these wall elements **45** is of trough-like configuration, being extended across the entire width of the conveyor; and it is contemplated that these elements have a flat lower surface and that they be mounted in close proximity to the upper surface of the conveyor flight **10a**, thereby providing sealing action preventing any substantial lateral flow or leakage of the high pressure gas being used in the high pressure manifold system. In a typical installation, in the normal operating position of each wall element **45**, the element will be spaced from the upper surface of the flight **10a** a distance of the order of a few millimeters, for instance, from about 3 to 5 mm.

These displaceable sealing wall elements are provided so that the sealing elements may be normally positioned much closer to the conveyor than would be possible if they were fixed in position. Displacement away from the conveyor will readily occur in the event of the accumulation on the conveyor of irregular deposits of resin or fibers, as tends to occur from time to time in the operation of such equipment. Since the elements **45** are automatically displaceable, if a lump or deposit is encountered, no damage to the equipment will occur,

even when the wall elements are mounted for normal operation very close to the surface of the conveyor.

The elements **45**, located above the conveyor, function automatically under the action of gravity to return to the position in close proximity to the conveyor, after being displaced by any deposit of resin or fibrous material. The width of the flat bottom surface of each of the trough-shaped elements **45** is preferably at least as great as any two adjacent passages between ribs **32** of the conveyor links **11**, so that the desired sealing function will be performed, regardless of the relative position of the ribs **32** with respect to the wall elements **45** in a direction along the path of movement in the conveyor.

Similar displaceable wall elements **48** are associated with the flight *8a* of the lower conveyor, these wall elements being arranged for downward displacement away from the lower surface of the conveyor flight *8a* and being urged upwardly by springs **49**. Similar pivots and limiting stops are provided for the lower elements **48**, but the lower elements being displaceable downwardly under the action of obstructions encountered as the conveyor flight passes the high pressure system, springs instead of gravity are relied upon to return the wall elements **48** to their normal operating position.

Each of the wall elements **45,45** and **48,48** is provided with an inclined surface, such as indicated at **50**, at the upstream side of the element, in order to facilitate the displacement action under the influence of foreign bodies carried by the conveyors.

From FIGS. *1b*, 3 and 4, it will be noted that in the high pressure manifold system **HP1**, the supply manifold **33** is located above the conveyor and in the upper circulation box **19** of the low pressure zone E with which the low pressure gas supply connection communicates, the discharge manifold of this high pressure system **HP1** being located in the discharge box **18** below the conveyor in the low pressure zone E.

By reference to FIG. *1b*, it will also be seen that in the low pressure zone F, the high pressure system **HP2** is inverted with relation to the arrangement shown in zone E. Thus, in FIG. *1b*, the high pressure supply manifold **33** is located below the mat in the low pressure supply box **18** of zone F and the high pressure exhaust manifold **38** is located above the mat in the low pressure exhaust box **19** of zone F.

In the alternative arrangement of FIG. *1c*, two high pressure circulation systems are shown as mounted within a single pair of low pressure boxes **18** and **19**. Thus, in this alternative embodiment, the high pressure supply manifolds **33***a* and **33***b* are located in the low pressure box **19** above the mat in side-by-side relation with an intervening displaceable sealing wall element such as the sealing elements described above in connection with FIG. 3; and the cooperating high pressure exhaust manifolds **38***a* and **38***b* are mounted within the low pressure exhaust box **18** below the mat, with a displaceable wall element lying between the two high pressure exhaust manifolds of the type described above in connection with FIG. 3. Outboard displaceable wall elements are also associated with the high pressure manifold systems of FIG. *1c* in the manner which will now be understood.

Although the high pressure air circulation systems contemplated according to the present invention may be employed in association with any of the treatment zones, A to F, it is particularly advantageous to employ such high pressure circulation systems in association with the low pressure circulation boxes downstream of about the mid region of the feed path and preferably at least ⅔ of the length of the feed path from the entrance end of the oven. Thus, in accordance with one preferred embodiment appearing in FIGS. *1a* and *1b*, two high pressure circulation systems are indicated in general at **HP1** and **HP2**, these being located respectively within the low pressure zones E and F, being the last two in the embodiment of FIGS. *1a* and *1b*.

Where two high pressure systems are incorporated in a single pair of low pressure boxes, it is preferred to arrange the two high pressure supply manifolds at the same side of the mat, and preferably within the low pressure supply box, because this will minimize leakage problems, with consequent loss of heat.

OPERATING CONDITIONS

As will be understood, the operating conditions will vary in accordance with a number of factors, including the thickness and density of the mat being formed, the compositon and characteristics of the binder being used, and also the amount of binder employed. However, some general guidelines, with regard to the operating conditions, are presented herebelow.

First, it is contemplated that the low pressure circulation established by the circulation boxes **18** and **19**, in the zones A to F inclusive, should include some zones in which the gases pass upwardly through the mat, and some zones in which the gases pass downwardly through the mat. Also, it is contemplated that the gases circulated through the boxes **18** and **19** in different zones may be at different temperatures, depending upon the characteristics of the mat and the binder used, as is already known in the operation of mat curing ovens having multiple zones of treatment. An appropriate temperature range for the gas supplied to circulation boxes **18** and **19** is from about 150° C. to about 300° C., when employing common types of fiber binders, such as phenol formaldehyde binders.

The pressure conditions established may also vary, and these pressure conditions may be measured in various ways. The pressure in the supply box and the pressure in the exhaust box will, of course, vary because of the drop in pressure incident to passage of the gas through the mat. In typical operating conditions, the pressure in the supply box of the low pressure systems may be of the order of from about 5 to 30 mm of water.

With regard to the high pressure circulation systems, it is contemplated that where more than one such system is utilized, for instance, in the configuration illustrated in FIG. *1b* where one high pressure system **HP1** is located in low pressure zone E and another high pressure system **HP2** is located in low pressure zone F, it is contemplated that one of these high pressure systems should be arranged to pass the treatment gas through the mat in one direction and the other high pressure system be arranged to pass the gas through the mat in the opposite direction. Thus, as indicated by the arrow in FIG. *1b*, the high pressure system **HP1** is shown as delivering the gas downwardly and the high pressure system **HP2** is shown by the arrow as delivering the gas upwardly. This will serve to maintain substantial uniformity of the treatment throughout the thickness of the mat.

With regard to the pressure and temperature employed in the high pressure systems, it is further pointed out that some benefit may be achieved by the employment of both low pressure and high pressure systems in combination in the same curing oven, even if the tem-

perature of the high pressure system is not higher than or even lower than the temperature in the low pressure system. The reason for this is because the high pressure will cause more rapid and effective penetration of the heat to the interior of the mat than is the case with the low pressure system.

The high pressure system may be operated over a substantial range; but in general, should be at least several times, preferably at least 10 to 20 times, the pressure of the low pressure system. For example, the pressure in the supply manifolds of the high pressure systems may be upwards of about 300 to 600 mm of water.

In a typical case where the temperature of the air in the low pressure systems is from about 150° C. to about 300° C., the temperature in the high pressure systems may desirably be from about 200° C. to about 350° C.

In a typical installation, the high pressure systems may have a discharge flow of about 5,000 Nm^3/h, when the discharge flow of the low pressure circulation system is about 30,000 Nm^3/h. The high pressure gases are concentrated in the localized relatively small areas as compared with the low pressure gases, and those localized areas in a typical case may comprise about 10% of the area of the treatment zones established by the low pressure boxes.

The temperatures and pressures will also vary depending upon the speed of advancement of the mat being formed and on the number of treatment zones in the mat curing oven. The use, according to the invention, of both high and low pressure air circulation systems, is particularly effective from several standpoints, including the fact that for given binder curing effect, this may be accomplished in fewer treatment zones and with a substantially shorter overall length of the curing overn. This is due to the fact that the high pressure systems are particularly effective in bringing the interior portions of the mat up to curing temperature in a short time. It is also advantageous that the high pressure systems will rapidly bring the temperature of the binder to the level where exothermic reaction will occur even in the core portion of the mat; and this temperature will then be maintained more readily, even beyond the localized area of the high temperature manifolds.

We claim:

1. Apparatus for heat treating a fibrous mat carrying a heat hardenable fiber binder comprising conveyor mechanism for advancing the fibrous mat through a feed and treatment path, a pair of gas circulation boxes arranged at opposite sides of the mat in said path and defining a treatment zone in which gas is passed through the fibrous mat between the circulation boxes, gas supply and exhaust ducts respectively connected with said circulation boxes and providing for passage of heated gas through the fibrous mat in said treatment zone, a pair of supply and exhaust gas circulation manifolds positioned within said circulation boxes and defining a localized treatment area within and smaller than said treatment zone, and heated gas circulating means associated with said manifolds and circulating heated gas through the fibrous mat at a pressure higher than that of the gas passed through the fibrous mat between said circulation boxes.

2. Apparatus as defined in claim 1 in which the conveyor mechanism comprises a pair of perforated endless conveyors having spaced conveyor flights presented toward the fibrous mat to engage and advance or feed the mat through the treatment path, the gas circulation boxes being disposed at the outboard sides of said conveyor flights and having openings presented toward said flights for circulation of heated gas through perforated conveyors and through the fibrous mat between said flights, and further characterized in that said circulation manifolds are defined in part by a wall element lying adjacent to a flight of one of said perforated conveyors, and mounting means providing freedom for displacement of said wall element away from the adjacent conveyor flight.

3. Apparatus as defined in claim 2 in which the wall element is positioned above the conveyor flight and is displaceable upwardly away from the conveyor flight and is downwardly moveable toward the conveyor flight under the influence of gravity, and stop means limiting downward movement of the wall element toward the adjacent conveyor flight.

4. Apparatus as defined in claim 2 in which the wall element is positioned below the conveyor flight and is displaceable downwardly away from the conveyor flight, means urging the wall element upwardly toward the conveyor flight, and stop means limiting upward movement of the wall element toward the conveyor flight.

5. Apparatus as defined in claim 1 in which at least two pairs of gas circulation manifolds are provided defining at least two localized treatment areas each within and smaller than said treatment zone, the pairs of manifolds being spaced from each other upstream and downstream of the feed path of the fibrous mat.

6. Apparatus as defined in claim 5 in which the supply manifolds of said pairs are located in the circulation box at one side of the feed path and in which the exhaust manifolds are located in the circulation box at the other side of the feed path.

7. Apparatus as defined in claim 5 in which the supply manifolds of said pairs are located in the supply circulation box at one side of the feed path and in which the exhaust manifolds of said pairs are located in the exhaust circulation box at the other side of the feed path.

8. Apparatus as defined in claim 1 in which a plurality of pairs of circulation boxes are arranged at opposite sides of the feed path, and in which a plurality of pairs of circulation manifolds are provided, at least one pair of manifolds being positioned with one pair of circulation boxes and at least one pair of manifolds being positoned in another pair of circulation boxes.

9. Apparatus as defined in claim 2 in which the conveyors each comprise a series of interconnected links having reinforcing ribs spaced from each other in a direction paralleling the feed path, and in which the displaceable wall element has a dimension in a direction paralleling the feed path at least twice the gap separating two adjacent reinforcement elements of the conveyor links.

* * * * *

United States Patent [19]

Marcus

[11] **Patent Number: 4,940,502**

[45] **Date of Patent: Jul. 10, 1990**

[54] **RELATING TO BONDED NON-WOVEN POLYESTER FIBER STRUCTURES**

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[73] Assignee: **E. I. du Pont de Nemours and Company**, Wilmington, Del.

[21] Appl. No.: **290,385**

[22] Filed: **Dec. 27, 1988**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 921,644, Oct. 21, 1986, Pat. No. 4,794,038, which is a continuation-in-part of Ser. No. 734,423, May 15, 1985, Pat. No. 4,618,531.

[51] **Int. Cl.**^{5} **B32B 31/20**

[52] **U.S. Cl.** **156/272.2**; 156/296; 264/123; 264/126; 428/296

[58] **Field of Search** 156/245, 296, 272.2; 264/123, 126; 428/296

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,663,225 5/1987 Farley et al. 264/126

Primary Examiner—James J. Bell

[57] **ABSTRACT**

A process is provided with apparatus for molding fiberballs into bonded polyester fiber structures in a continuous line system, whereby novel structures may be economically provided with advantages over bonded batts.

5 Claims, 2 Drawing Sheets

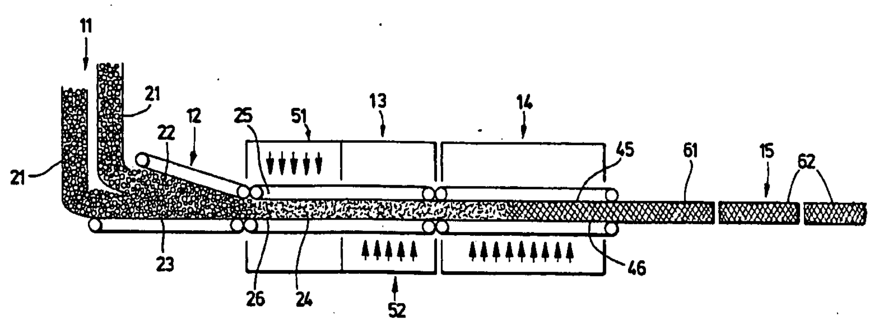
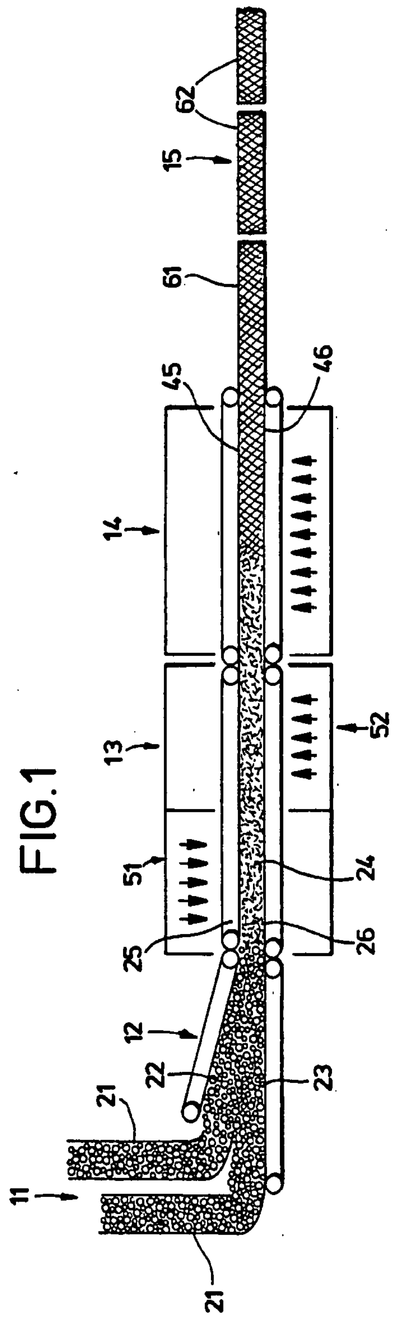


FIG.1



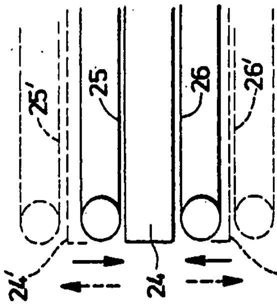


FIG. 4

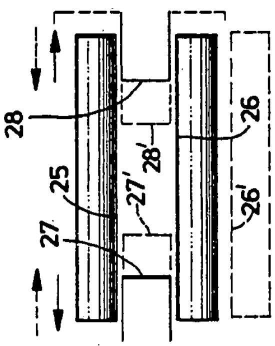


FIG. 3

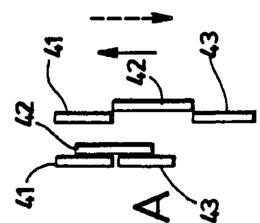


FIG. 6A

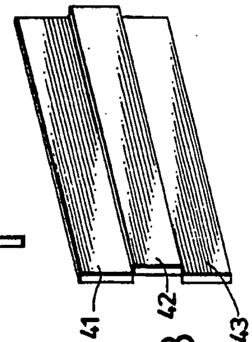


FIG. 6B

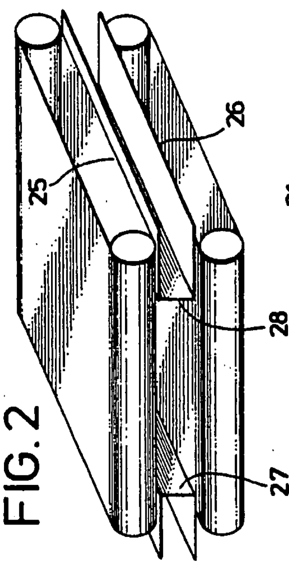


FIG. 2

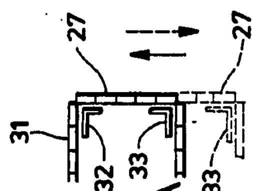


FIG. 5A

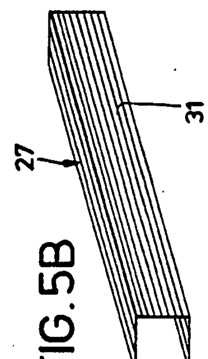


FIG. 5B

RELATING TO BONDED NON-WOVEN POLYESTER FIBER STRUCTURES

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of my parent application Ser. No. 06/921,644, filed Oct. 21, 1986, to be issued as U.S. Pat. No. 4,794,038, Dec. 27, 1988, itself a continuation-in-part of my grandparent application Ser. No. 734,423, filed May 15, 1985, now issued as U.S. Pat. No. 4,618,531, Oct. 21, 1986.

TECHNICAL FIELD

This invention concerns improvements relating to bonded non-woven polyester fiber structures, and more particularly to a new process and apparatus providing novel bonded polyester fiber structures from fiberballs of the polyester fiber blended with binder fibers (of lower melting and softening point than the load-bearing polyester fiber), that are bonded to provide useful new through-bonded structures.

BACKGROUND OF THE INVENTION

Thermally-bonded polyester fiber batts are described in my parent U.S. Pat. No. 4,794,038 (and in many other documents, including, e.g., U.S. Pat. Nos. 4,668,562 and 4,753,693, and WO 88/00258, corresponding to Ser. No. 880,276, filed June 30, 1986), and such batts have gained large scale commercial use, particularly in Europe and Japan. Binder fibers can be intimately blended into the load-bearing polyester fiber to achieve true "through bonding" of the polyester fiber when they are suitably activated. "Through bonding" has provided higher support and better durability than resin-bonding of polyester fiber, which was the conventional method, and can also provide reduced flammability than conventional resin-bonding. Binder fiber blends are now used on a large scale to make batts in furnishing, mattresses and similar end uses where a high support and good durability are required. They have, however, seldom been used as the only filling material in these end uses, but the common practice is to use the polyester fiber batts as a "wrapping" around a foam core. It is believed that the main reason is that it has been difficult to achieve the desired properties without using the foam core. To achieve the desired resilience and durability, bonded fiber batts would have to reach high densities, in the 35 to 50 kg/m^3 range. Such high densities could not be achieved commercially until very recently. Even then, such condensed (i.e. high density) batts as have appeared on the market in Europe and the U.S. (e.g., in 1987) have been nonuniform in density, lower layers being denser than upper layers, which results in increased loss of height during use. These high density "block batts" (as they have been referred to) have also been characterized by relatively poor conformation to a user's body. I believe that this results from their structure, since the batts are made from a series of superposed parallel layers; when these parallelized structures are deformed under pressure, they tend to pull in the sides of the whole structure rather than to deform more locally, i.e., to conform to the shape and weight of the user's body, as would latex or good quality polyurethane foam.

Thus, hitherto, the performance of existing "block batts" made wholly from bonded polyester fiber has not been entirely satisfactory. The difficulty has been how to combine in one structure both durability and conformability to a human body. To obtain durability, with existing "block batts" from superposed carded webs, one has had to increase the density until one obtains a structure that does not conform as comfortably as other structures, i.e. not wholly from bonded polyester fiber. I have now solved this problem according to the present invention.

As will be apparent hereinafter, an essential element of the solution to this problem (i.e. of the present invention) is to use a binder fiber blend in a 3-dimensional form, as fiberballs, rather than as flat webs or as a formless mass of fibers. This may seem surprising, but the advantages will be explained, hereinafter. Preferred fiberballs (and their preparation and bonding) are the subject of my parent U.S. Pat. No. 4,794,038, referred to above, the disclosure of which is hereby incorporated by reference, it being understood, however, that other fiberballs may be used in the present invention, as indicated later herein.

SUMMARY OF THE INVENTION

According to one aspect of the invention, there is provided a continuous process for making a molded block of bonded polyester fiber having a cross-section of predetermined dimensions from a blend of polyester fiber with binder fiber, characterized in that fiberballs, consisting essentially of said blend, are formed into a shaped mass, that has a cross-section with a dimension that is larger than one of said predetermined dimensions, and that is continuously advanced through a compressing stage, in which said mass is compressed transversely, and wherein said binder fiber is activated and caused to bond the polyester fiber by first heating and then cooling the mass while said mass is maintained in compressed condition. Generally, the resulting molded block will be cut into convenient lengths, as described hereinafter, but it will be recognized that many variations are possible in this and in other respects, to take account of the versatility of the new fiberball techniques and system described herein, with addition to and/or replacement of, as appropriate, the materials and/or apparatus elements and/or conditions mentioned herein, and in my parent Patent, with particularly regard to the fiber materials that are preferred; the present application is more particularly directed towards process and apparatus aspects than to materials.

According to another aspect, there is provided an apparatus for forming a molded block of bonded polyester fiber having a cross-section of predetermined dimensions from fiberballs consisting essentially of a blend of polyester fiber and of binder fiber, comprising means for arranging the fiberballs into a shaped continuous mass having a cross-section with a dimension that is larger than one of said predetermined dimensions, means for forwarding said shaped mass through sequential compressing, heating, and cooling stages, means for compressing said mass transversely of the direction of forwarding, and means for heating and for subsequently cooling said mass while maintained in compressed condition.

New bonded fiber products result and are characterized by improved resilience, durability and conformability over the "block batts" available hitherto, as will be explained hereinafter. In essence, my new process and apparatus provides new structures that I refer to as

"molded (fiberball) blocks", produced from fiberballs containing binder fiber, wherein the binder fiber has been intimately blended into the load-bearing fiber. It is often possible to detect the original ball structure from which the bonded structures have been derived and prepared, depending on the materials and conditions used. The fiberballs are conveniently laid down on a moving belt and compressed to the desired density and shape, and it is important that they be maintained in a compressed condition, e.g. between perforated members (e.g., upper and lower advancing plates or grids) and also between side walls during oven bonding and cooling, prior to any cutting. Resulting structures can be made to have high resilience, good conformability to the user's body, and good durability. Surprisingly, these structures have shown similar durability to prior art-type block batts made from the same fiber blend, but at 25% lower density than the block batts. They can be made in a large range of densities, according to the desired end-use requirements. Such continuous molding equipment may be completed, if desired by "in line" transformation of the resulting "molded fiberball blocks" into finished mattresses, cushions, or other articles. It is comparatively easy to perform further conventional steps, such as shaping, embossing, trimming, etc. . . . if desired.

This new system according to the invention provides also a speedy method of making low density products, and can be adapted to produce products of increased density, with flexibility, and over a wide dpf (denier per filament) range.

For practical reasons, it is desirable that a variety of differently-(predetermined-)dimensioned articles be obtainable from the same molding apparatus, and so I have devised means for achieving this flexibility, while ensuring that the fiberballs be maintained confined in a compressed condition in a moving "box" during the activation of the binder fiber and its solidification and/or hardening to provide the resulting bonded structure, so that it retains the desired shape and predetermined cross-sectional dimensions. These means are described in greater detail hereinafter.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 illustrates in side-elevation an overall view of a preferred apparatus according to the invention to illustrate how fiberballs may be processed into a molded block and cut according to a preferred process according to the invention.

FIG. 2 is a view in perspective of a portion of the apparatus illustrated in FIG. 1, said portion being referred to as the "box" in which the fiberballs are confined while under compression during the heating and cooling stages.

FIGS. 3 and 4 are different views in side-elevation of the same "box" to illustrate how the retaining "walls" of the "box" may be adjusted to permit variation of the desired cross-sectional dimensions of the resulting molded block.

FIGS. 5A and 5B, and 6A and 6B, are views of alternative embodiments to show how the height of the side walls of the "box" maybe adjusted.

DETAILED DESCRIPTION OF THE INVENTION

A "molded (fiberball) block" according to the invention has a completely different structure and properties than the prior "block batts"0 referred to above. In the prior "block batts", the fibers have been essentially parallelised in planes, because such batts have generally been built up by superposing several webs, and most pressures applied in use are exerted perpendicularly to the fiber length. To achieve high durability with this parallelised structure one has been forced to compress to a very high density.

High density block batts tend to become too rigid, and pull in on their sides when deformed, for example under a sitting person, rather than deform more locally and conform to the contours and weight distribution of the individual sitting thereon. In "molded (fiberball) blocks" the structure is very different. In the bonded fiberballs the fibers have strong perpendicular components and, when compressed, the bonded fiberball behaves like a small spring with a high resistance to compression. The forces which bond the fiberballs to each other are generally much weaker than the forces which resist the compression of the individual balls. This can be desirable, as it provides very high resilience on the one hand, and good local deformation in response to pressure on the other hand.

If required according to certain end-uses, it is possible to provide increased bonding strength between the fiberballs by blending the fiberballs with binder fibers prior to molding, as disclosed in my parent Application. Such binder fibers should desirably be randomly distributed between the fiberballs, before the material enters the lay down system, to provide a more rigid molded block (throughout) which does not mold itself as well to the user's body but has a higher resilience. However, as disclosed hereinafter, by appropriate adjustment and control of the materials fed to the apparatus, if desired, variation of the bonding may be achieved, e.g. across the cross-section.

The softness of the molded product of the invention generally depends on appropriate selection of the fiber denier, fiberball structure, polyester fiber/binder fiber ratio, the density of the molded product and the bonding conditions, especially the temperature. In some cases, where a high density is needed in order to reach the required durability, it may be difficult to achieve at the same time good conformation to the user's body, i.e. conformability, as the structure may become too rigid. In such cases the flexibility and the softness of the molded structure may be very substantially increased by producing the fiberballs for the molding operation from a blend of binder fibers with fibers coated with a segmented copolymer composed essentially of polyalkylene oxide and polyethylene terephtalate, as disclosed in my parent Application. The coating should be preferably cross-linked to reduce any losses of material from the coating due to the heat treatment during molding. Such hydrophilic coatings import some additional advantages to the molded product of the invention by increasing its moisture transport and improving conformation without loss of bonding strength.

The fiberballs which are suitable for the molding process according to this invention have preferably a round configuration with a certain hairiness on the surface of the balls. The optimal surface smoothness of the fiberballs may often be a compromise; a very smooth surface generally helps to distribute the balls more easily across the width of the mass, but may likely reduce the ability of the fiberballs to bond to each other. The fiberballs for the practice of this invention may be produced from a blend of binder fiber and spirally-crimped fiber, according to my parent Application, or

from blends of binder fibers with mechanically-crimped fibers, it being understood that fibers may be used with both mechanical and spiral crimp, e.g. superposed on the same fiber. The fiberballs produced from the spirally-crimped fiber/binder fiber blends are generally preferred, as I have found it easier to achieve a better distribution (e.g., during the lay down process) and as they generally have a better fiberball structure, which also helps the durability of the molded block. For producing the "molded (fiberball) blocks" of the invention, both fiber components are desirably intimately blended in the original fiberballs to provide for good through bonding of the polyester fiber. The fiberballs themselves generally have a random structure, and provide a more regular or uniform density throughout the molded structure, in contrast to the tendency of condensed batts to be denser in their lower layers. In contrast with some other applications of fiberball structures, such as my grandparent U.S. Pat. No. 4,618,531, it is not generally desirable for the present invention to have such a very low cohesion. A certain hairiness is generally desirable to allow the necessary bonding between the fiberballs to achieve the required block integrity. The molding of fiberballs containing binder fiber in a discontinuous process was described in my parent Application. I have found "molded (fiberball) blocks" according to the invention have had higher resilience and better durability than "block batts" having the same average density. Without limiting the invention to any theory, one may speculate that the advantage of the fiberball molded structures may be explainable by the difference in structure of the block as discussed herein. The discontinuous fiberball molding process can be very useful for small series of production, such as furnishing cushions, which require frequent changes of the shape of the article. For mattress cores and similar articles of a larger size the discontinuous molding process is not generally so attractive economically. Mattresses in particular are flat and rectangular and generally have more or less the same length. This makes it advantageous to produce them in a continuous process. However, many problems, which do not exist in "block batts", had to be overcome before a process for a continuous molding of fiberballs could be developed.

In manufacturing of "block batts", the fibers have been opened and carded to form webs that have been cross-lapped to produce the batts. The batts have then been superposed one on top of each other, to produce the desired weight per unit area, and then compressed with rolls or belts, to reduce the height to the desired level. The condensed batts have entered an oven, where they can sometimes be compressed more, and hot air has blown through. I believe that the air pressure has maintained the integrity of such batts compressed and with the melting of the binder fibers the whole batt has lost its resilience and so it was not believed to be absolutely essential to maintain such batts compressed during the bonding process, although such equipment may have been available, and, in some cases, the block batts may have been confined to maintain their shape, especially their desired thickness, even during cooling. The "block batts" have then been cooled and cut in line. The batt integrity has been kept through the whole process because of the cohesion between the fibers within the webs and between the webs. In other words, there has been no need to guide a batt through the oven in a "box" between perforated belts or metal grids or similar protective devices, as there has been little real fear that the batt would have been blown away, e.g. at its sides, during the hot air bonding.

This same cohesion has made any compressing stage relatively simple, as the batts have been compressed in a regular way, without serious sideways shifting of the fibers.

Producing the "molded fiberball blocks" of the invention presents more complication, because the fibers are in fiberball form, which can and would move sideways when pressure is applied and would be blown away by hot air streams in the oven, unless precautions are taken, such as have not generally proved needed in practice when bonding carded batts. To solve these problems, I have invented continuous molding equipment, whereby the fiberballs are always maintained confined in three dimensions as they are constantly forwarded through during the compressing, oven-bonding, and cooling process stages.

Referring now to the assembly-line embodiment illustrated schematically in FIG. **1**, a complete line may comprise, in addition to a fiberball-making unit (not shown, but which can be as disclosed in my parent Pat. No. 4,794,038, or by another ball-making technique) lay down equipment in a section indicated generally as **11** so as to form a loose, regular, 3-dimensional structure with a controlled weight per unit area and a regular thickness across its full width, a compressing section, indicated generally as **12**, comprising two moving belts that are inclined towards each other as they advance the fiberballs, so as to compress the fiberballs, while they are contained between two side walls (not shown), an oven indicated generally as **13**, a cooling zone indicated generally as **14**, and a cutting zone, indicated generally as **15**.

As indicated, the fiberballs constitute an essential element of the present invention. A preferred method of making preferred balls is described in my parent Application, the disclosure of which has been incorporated by reference. This provides information on the materials that may be used, as will be understood by those skilled in the art of bonded structures, but should be modified as described herein, and may be further modified by varying the materials and structures and conditions, as will be evident to those skilled in such arts.

The laydown section **11** may be conventional and feeds the balls (indicated generally as **21**), into compressing section **12**, which conveniently comprises a pair of cooperating continuous belts that advance the balls between an upper belt **22** and a lower belt **23**, the lower belt conveniently providing a horizontal advancing floor to support the mass of balls as they are advanced, while the upper belt is inclined so that the mass is compressed as it is advanced towards oven **13** between sidewalls (not shown).

The resulting compressed fiberball mass **24** is guided into the oven where it is carried along between upper and lower continuous grids or perforated plates in the form of belts **25** and **26**, and two side walls, **27** and **28**, all of which maintain the fiberballs in compressed condition, throughout the oven **13** and the cooling section **14**, as shown also in FIG. **2**.

Referring now to FIG. **3**, the positions of the side walls **27** and **28** may be adjusted horizontally to increase or decrease their spacing, and so, correspondingly, the width of the compressed fiberball mass therebetweeen, as shown by the dotted line positions **27'** and **28'**.

Referring now to FIG. **4**, the positions of the upper belt **25** and of the lower belt **26** may be adjusted verti-

cally to increase or decrease their spacing, and so, correspondingly, the height of the compressed fiberball mass 24 therebetween, as shown by the dotted line positions 25' and 26' (and 26' also in FIG. 3), and also the corresponding dotted line upper and lower extents of the compressed fiberball mass 24'.

Thus, the dimensions of the cross-section of the compressed fiberball mass may be adjusted and predetermined. The positions of the plates 25 and 26 may be changed by lifting or lowering a hydraulic system to accomodate the desired product thickness. The height of the side walls may be changed as well to keep the mass completely confined and avoid fiberballs escaping or being blown away. Depending on the flexibility requirements of the equipment, the side walls may be made, e.g., from thin plates which are sliding one on top of the other, or from a lamellar structure.

As will be understood, the arrangements described and illustrated in these Figures for the oven 13 and for the cooling zone 14 are essentially similar in these respects.

FIGS. 5A and 5B show a side wall 27 with a lamellar structure. Such side walls are made of thin lamella 31, connected by flexible wires (e.g. thin rope of Kevlar® aramid fiber) supported on metal frames 32 and 33. The dotted line positions of the lower frame 33', and of the side wall 27'' show how the adjustment can work in practice. This system allows the production of a wide range of product thickness from very thin to very thick by changing the thickness by little steps, e.g. of 5 mm. It has the advantage of providing a smooth, clean side wall which imparts a similar clean face to the resulting molded block, without the need to cut it or correct it by contact with a hot surface.

FIGS. 6A and 6B show another possibility of changing the height of the molded products of the invention. This wall is composed of several thin plates (three being shown) 41, 42 and 43 which can slide past each other to change the total height of the side wall. These plates would be supported in practice by adjustable means (not shown), such as frames at each end with locking pins or other means. As shown in FIG. 6B this system for the side wall will result, unless corrected later in the process, in slight marks or indentions on the sides of the molded block.

To modify the width of the fiberball molded blocks, one may (1) change the width of the lay down; and (2) advance or withdraw the side walls 27 and 28. To change the height, one may (1) adapt the lay down and the belt speeds; (2) adjust the gap between the upper and the lower perforated plates or grids 25 and 26; (3) adjust the height of the side walls 27 and 28 to the gap between them.

It is important to ensure that the product is maintained completely confined during both the heating and the cooling process, i.e., it is not sufficient merely to confine during the heating stage. Any stray material that may escape is conveniently removed by suction or other conventional means.

To ensure uniform bonding for the molded fiberball blocks, the hot air oven is preferably divided into two or more sections with the possibility to reverse the direction of the air flow between such sections, as shown generally in FIG. 1 at 51 and 52. To obtain a product with a consistent resilience and durability it is preferred that the temperature of the air flow is controlled within a narrow range, preferably such as $\pm 5°$ C. This may be difficult to achieve with some conventional oil or gas heating due to the relatively slow response of such a system. Improved temperature control may be achieved economically by combination of an oil or gas heating system with electric heating, whereby, e.g., about 80–90% of the necessary or expected energy is generally produced by the oil or gas heating, but the electric heating (which may conveniently be located just above the perforated plates) supplies the additional calories and can quickly react to changes in temperature to maintain better temperature control. Dielectric heating means, such as by using microwaves, are expected to provide very convenient means of heating, when properly adapted.

The (fiberball-derived) structures have been found to have a much higher air permeability than block batts of the same density made from the same fiber blends. This makes it possible to achieve the desired bonding with a much shorter oven, thus reducing investment and energy consumption.

From the oven, reverting to FIG. 1, the molded block is advanced to a cooling zone 14, where it is maintained totally confined until it reaches an appropriate temperature, preferably below 50° C., so that it cannot be permanently deformed by pressures which are within the normal range of the use of the product, it being understood that the optimum conditions may depend on the particular materials selected for use. The cooling zone 14 is essentially similar to the arrangement for the oven 13, i.e. with an upper perforated grid or plate in the form of a belt 45 and a similar lower belt 46, and sidewalls (not shown in FIG. 1) but with cooling air directed as shown, or as may be convenient.

A substantial part of the energy can be recovered in the cooling zone and used to heat the air intake of the system.

From cooling zone 14, the molded mass 61, in the form of a continuing advancing column, preferably passes to a cutting zone 15, and is cut conveniently by means (not shown) to make separate blocks 62, of whatever length is desired and may be further treated as indicated, if desired.

A basic advantage of the fiberball molded blocks over the block batts is that the fiberball molded blocks can be provided to have a much more regular density, i.e. comparing top to bottom. The block batts usually show a substantial difference in density, with the bottom part having a significantly higher density. This difference is caused by the packing of the layers under the fibers' own weight due to the reduced resilience of the hot fibers. The melting of the binder fiber also contributes to their pulling down the mass of fibers as they shrink and to their sticking to the load-bearing fibers. In the case of the fiberballs, this phenomenon may be very much reduced due to their superior resistance to crushing at the practical working temperatures suitable for the fiberball structures. In the fiberball structure, there is practically no pull down by the binder fibers and the structure itself is more resistant to deformation than compressed batts of a comparable density.

The fiberball continuous molding process disclosed herein can be easily modified, if desired, to produce blocks with a profile of density, having, for instance, an increased density in the middle. This can be done conveniently by modifying the lay down system. A reinforced central section may be advantageous for some applications, particularly mattresses, to compensate for the higher pressure in this area. This may allow one to provide, in a simple process, mattress core with a rein-

forced middle part, whereas, previously, this was produced by cutting various foams with different densities and gluing them together.

It will also be understood that, although the process has a significant advantage in providing the capability of making bonded structures from polyester load-bearing fibers, by using binder fibers, without the need for other materials, it may in some instances, be convenient and more desirable to incorporate other materials. As indicated, in addition to the fiberballs, that are an essential structural element and predecessor material of the final molded structures, other materials may be incorporated, e.g., other fibers, such as additional binder fibers (to provide more or less bonding if desired between the ball structures), conveniently, e.g., of cut length from about 15 to about 50 mm. The fiber constituents of the balls may conveniently be of cut length up to about 100 mm, e.g., about 10 to about 100 mm, and of dpf (denier) about 2 to about 30, depending on desired aesthetics and intended use, with balls generally of dimensions (e.g., approximate diameter) up to about 20 mm (depending on aesthetics), e.g., about 2 to about 20 mm, and binder fiber desirably of melting point 50° C. or more below that of the load-bearing fiber, it being the adhesion capability below the softening point of the load-bearing fiber that is important. The characteristics of the resulting molded structures will depend on customer taste and fashion, but the densities will generally be of the order of about 20 to about 80 kg/m3 and 10 to 200 mm thick.

An interesting use of the invention and of the products is to make a molded block as an intermediate for further processing in various ways that will become apparent. For instance, the process and apparatus may be run at high speed to make low density bonded product that is sufficiently lightly bonded to be fracturable into conveniently sized particles for use as such, or themselves to be used as intermediates for further processing. Thus, by use of the process and apparatus of the invention, it is possible to provide small particles of bonded polyester by a continuous low cost operation. These particles may be used as filling material themselves, as disclosed in my parent Application, or in EP Published Application 277,494, or as insulation otherwise, or for any use that may be appropriate depending on the particular materials used and their density, size and other properties. A machine that is generally used to tear apart textile waste, such as is commercially available from the Laroche firm in France, may be used or adapted to tear apart the molded block that issues from the present invention as a continuous operation, or as separate stage, as may be desired.

Although this process and apparatus has been disclosed more particularly in relation to making molded blocks from bonded polyester fiber, because I am aware that there are already in existence many commercial operations that are involved in making products from bonded polyester fiber, it will be apparent that the apparatus and process of the invention are not limited to processing only polyester fiber, but other fibers, such as polypropylene and natural fibers and mixtures of fibers may be processed into bonded products by the same concept of the present invention, provided a suitable binder fiber is used in conjunction with such other fibers, and provided that the conditions are not such as to affect deleteriously (i.e. in an undesirable way) the fibers or the properties desired in the resulting products. Polyester, because of its properties, has proved to be especially adapted for use with existing binder fibers that have been especially designed for compatibility with polyester fiber.

I claim:

1. A continuous process for making a molded block of bonded polyester fiber having a cross-section of predetermined dimensions from fiberballs consisting essentially of a blend of polyester fiber with binder fiber, characterized in that said fiberballs are formed into a shaped mass, that has a cross-section with a dimension that is larger than one of said predetermined dimensions, and that is continuously advanced through a compressing stage, in which said mass is compressed transversely, and wherein said binder fiber is activated and caused to bond the polyester fiber by first heating and then cooling the mass while said mass is maintained in compressed condition.

2. A process according to claim 1, wherein the bonded mass is cut into separate blocks.

3. A process according to claim 1 or 2, wherein the mass is heated by passing heated air therethrough.

4. A process according to claim 3, wherein the mass is heated dielectrically.

5. A process according to claim 1 or 2, wherein the mass is heated dielectrically.

* * * * *